

conventional thin film, metallic traces. However, those skilled in the art will appreciate that these components can, if desired, be configured in alternate embodiments using MMICs.

- The first and second outputs of the data input means 102 are supplied as first and second channel inputs to the modulator 124, which sums the frequency  $f_1$  of the first channel input, and  $f_2$  of the second channel input. The modulator 124 can be configured using any available MMIC. A difference between  $f_1$  and  $f_2$  is also produced as an unwanted lower sideband, which is filtered from the transmitter. That is, the modulator 124 of the data processing means 104 supplies an output with, for example, a 7 dB loss to a bandpass filter 126 which bears a 5 dB loss and which removes the difference frequency  $f_1-f_2$ . The output from the bandpass filter 126 is supplied to an amplifier 128 which boosts the signal with a 9 dB gain over the signal path to an attenuator 130. An output from the attenuator 130 is supplied as the output of the data processing means 104, to the input of power output means 106.
- The power output means 106 receives the output from attenuator 130 via an amplifier 132, and supplies an output to a first 90° hybrid 134, such as a branchline coupler, for splitting the signal into two channels 136 and 138. In the Figure 1 embodiment, each 90° hybrid is configured using a conventional thin film, metallic trace. The amplifier 132 provides a 22 dB gain, and supplies the output to the hybrid 134. Outputs from the hybrid 134 are supplied to amplifiers 140 and 142, respectively which impart a 16 dB gain to the signals therein. Outputs from the amplifiers 140 and 142 are supplied to second and third hybrids 144 and 146, respectively. Hybrids 144 and 146 separate the inputs from channels 136 and 138 into four amplification channels 148, 150, 152 and 154, each possessing one of the amplifiers 156, 158, 160 and 162 for imparting a 7 dB gain to the signals therein.

Outputs from each of the four amplifiers in the amplification channels are supplied to fourth and fifth hybrids 164 and 166. The hybrids 164 and 168 recombine the signals from amplification channels 148 and 150 into a first power output channel 168 and a second power output channel 170. Signals in the power output channels 168 and 170 are supplied to a sixth 90° hybrid 172, which, with a .3 dB loss, supplies a

transmitter output signal with a 34.2 dB power to a transmitter microstrip line to coaxial connector 174. An output from the connector 174 is supplied via a connector to the information transmission means configured as the radio frequency output 108.

The 90° hybrids of the power output means 106 are identically configured, and  
5 are elements well known to those skilled in the art. Referring to the first 90° hybrid  
134, a load 176 is illustrated. This load is used to prevent reflections from the power  
amplifiers from influencing operation of the circuit. The hybrids permit the use of four  
separate, parallel stages, or channels, of amplification. Thus, to provide a 2 W output,  
each of the four channels can be configured with 0.5 W amplifiers, thereby achieving  
10 four times the power with the same compression, and achieving good distortion control.  
The hybrids split power evenly, and minimize signal reflections without substantially  
increasing circuit complexity. Those skilled in the art will appreciate that although the  
exemplary Figure 1 embodiment is illustrated as using the 90° hybrids, other circuit  
components can be used to achieve similar operation. For example, each of the 90°  
15 hybrids is a branchline coupler which can be replaced by other 90° hybrids, such as  
Lange couplers or air bridges having tightly coupled lines.

The radio frequency output 108 can be configured as a dual polarization (90°  
rotation of phase) antenna for establishing isolation between transmission and reception.  
This isolation can be achieved using, for example, two individual antennae separated by  
20 a distance, or by using a single antenna and an isolator. The use of polarization  
enhances the signal-to-noise ratio and therefore enhances the range for a given  
transmitter power output level and for a given receiver noise figure. Exemplary  
embodiments can achieve bit-error rates on the order of  $10^{-12}$  or lower and can achieve  
almost 100% availability.

Exemplary embodiments can use an antenna having a flat plate design, with  
25 printed dipoles, such as an antenna available from Malibu Research, Inc. The antenna  
can be configured with multiple planes, wherein one plane has different attenuation than  
another plane to achieve orthogonality. For example, the antenna can be configured for  
700 MHz offsets in transmit frequencies for channels operating in opposite directions,  
30 the offsets being generated by the offset of the intermediate frequencies between

transmit and receive frequencies at opposite ends of the communication link. In an exemplary embodiment, at one end of the communication link, the intermediate frequency into the transmitter is 2.325 GHz and the receiver output is 3.025 GHz; at another end, the transmitter uses an intermediate frequency of 3.025 GHz and the receiver is 2.325 GHz. This feature permits the transceiver to establish forward and reverse wireless information transfer channels which are isolated from each other.

The exemplary Figure 1 transmitter can be configured to use phase shift keying for modulation. However, those skilled in the art will appreciate that any modulation techniques known in the art can be employed.

Power supplies for each of the components illustrated in the Figure 1 transmitter are provided via an on-board transmitter voltage regulator or regulators. In an exemplary embodiment, three such voltage regulators can be included: a first regulator for the data input means 102 and data processing means 104, a second regulator for the portion of the power output means 106 used to establish the four amplification channels 148-154, and a third regulator for recombining the signals from the four power amplification channels into a single RF output. Of course, those skilled in the art will appreciate that a single regulator, or any number of regulators can be used to provide the power supplies to the various components of the circuits.

An exemplary voltage regulator which can be used for each of the three voltage regulators described in connection with an exemplary embodiment, is illustrated in Figure 2. Figure 2 shows an exemplary embodiment of a transmitter voltage regulator 200. In the exemplary embodiment shown, the regulator is a DC voltage regulator having a 0.3 voltage drop at 7 to 8 amps, with 1-3 W power dissipation. A low voltage drop can be achieved from the input to the output of the regulator through the use of components illustrated, such as the use of a pnp transistor as an output switch. Because the exemplary embodiment illustrated is a monolithic device, it is somewhat sensitive to the effects of high current. Accordingly, exemplary embodiments are configured with a means for protecting the circuit against high currents. For example, in the exemplary embodiments illustrated, if a proper negative voltage is not obtained as a gate bias control voltage, a positive voltage cannot appear at the drain bias output of the circuit.